

Introduction

Construction of the Going-to-the-Sun Road, which began in 1921, was a huge undertaking, even by today's standards. Construction of this Road made one of the most scenic parks in the country more accessible, allowing visitors to enjoy a pleasant drive, rather than days of hiking or horseback riding over rough terrain. Because of its unique character and historical significance, the Road has been declared a National Civil Engineering Landmark as well as a National Historic Landmark. These distinctions mean that a rehabilitation effort of any kind is not just an everyday engineering project. Special care must be taken to preserve not only the safety and functionality of the Road, but the history and visitor experience as well.

When the final segment of the Road was opened in 1933, the National Park Service (NPS) estimated 40,000 cars per year traveled on the Road. Today, the annual total is nearly 500,000 cars, carrying approximately two million visitors. This traffic volume, along with the effects of weather and time, have led to the deteriorating condition of this historic roadway. Since 1957, when the last section of the Road was paved with asphalt, rehabilitation projects have been infrequent and limited in scope, due in large part to limited funding. In 1982, Congress passed the Surface Transportation Assistance Act, which allowed the park to obtain Federal funding for road rehabilitation projects, rather than having to fund them from their general operating budget.

In 1999, Glacier National Park adopted a General Management Plan (GMP) to guide the management of the park for the next 20 years. Preservation and maintenance of the Road was one of the key priorities identified in the GMP. An Advisory Committee was established by authority of the Secretary of the Interior under Section 3 of Public Law 91-383 (16 U.S.C. 1a-2c) to review the rehabilitation alternatives and advise the park on the best course of action for rehabilitation of the Road.

Executive Summary

Under the direction of the park and the Advisory Committee, this engineering study was prepared to identify, explore and develop alternatives for rehabilitating the Road. It details the criteria, considerations and alternatives necessary to access the best available technology to reduce costs and mitigate impacts.

Time is of the essence for addressing the critical needs of the Going-to-the-Sun Road. Current conditions dictate that now is the time to slow and stop the deterioration of the Road and safeguard its historical features. Rehabilitation efforts must be expedited in order to assure the integrity of this landmark Road.

Road Rehabilitation Alternatives

This engineering study presents five alternatives for rehabilitating the Going-to-the-Sun Road. These alternatives represent a range of costs and schedules from which to rehabilitate the Road considering the engineering aspects; historic, cultural, and environmental factors; preservation of natural resources; and visitor impact. Engineering concepts in these alternatives were based on the selection of the historical treatment that would provide for preservation and rehabilitation of the contributing elements of the Road; the traffic control method that would provide for a moderate impact on visitors; and a prudent life cycle that would require a low to moderate level of long-term maintenance.

Alternative 1: Repair as Needed

The Repair As Needed alternative provides for basic operations and maintenance of the Road with \$2 million per year funding for rehabilitation efforts. Repairs are made without substantial pre-planning or design, based on the needs and priorities of the Road. Little opportunity exists for assuring that the historical, cultural, long-term maintenance, environmental, and visitor impacts are considered or mitigated. Work occurs on the Road when the Road is open to visitors. This alternative has the highest cost and duration, the most potential for major failures, significant delays, and unplanned road closures.

Summary of Alternative 1
Repair As Needed

*Traffic control requirements, and consequently, traffic delays,
are dictated by the problem and repairs needed*

Rehabilitation Cost Estimate (2001 dollars) \$ 97.7 to \$ 117.2 million
 Rehabilitation Duration Approximately 50 years
 Rehabilitation Cost (3% escalation per year)..... \$ 237 to \$ 284 million

Alternative 2: Priority Rehabilitations

The Priority Rehabilitations alternative provides for rehabilitation with \$5 million per year funding and includes planning and design in concert with the historical, cultural, environmental, socioeconomic, and long-term maintenance considerations. Visitor impact has a better opportunity to be mitigated as the work is planned and includes integrated traffic and visitor management in accordance with the current park's practice. Work occurs on the Road when the Road is open to visitors. Even though this alternative has a plan for rehabilitation, there is still a significant potential for major failures, delays and road closures.

Summary of Alternative 2
Priority Rehabilitations

*Current traffic control guidelines could be used which limit visitor delays to
fifteen minutes at each construction site, with a maximum of two sites,
one on each side of Logan Pass. Two-hour delays are allowed at night
three days per week, and two Friday afternoons in October.*

Rehabilitation Cost Estimate (2001 dollars) \$ 89.5 to \$ 107.4 million
 Rehabilitation Duration Approximately 20 years
 Rehabilitation Cost (3% escalation per year) \$ 128 to \$ 154 million

Alternative 3: Comprehensive Shared Use

The Comprehensive Shared Use alternative balances the needs of the rehabilitation with visitor use, and incorporates the engineering, historical, cultural, environmental, socioeconomic, and long-term maintenance considerations. Work proceeds on the Road while the Road is open to visitors; however, rehabilitation work that requires significant visitor delays is performed during times of low visitor use. A tremendous opportunity exists for overall effective scheduling and cost effectiveness in using this alternative.

Summary of Alternative 3 Comprehensive Shared Use

- *Five-minute delays, 10 a.m. to 2 p.m. Mon-Thu, 10 a.m. Friday to 7 p.m. Sun*
- *Five-minute delays on holidays, and from 10 a.m. to midnight on the day preceding a holiday*
- *30-minute delays, 7 a.m. to 10 a.m. and 2 p.m. to 7 p.m. Mon-Thu*
- *Delays of four hours or less, 7 p.m. to 7 a.m. Mon-Thu*
- *Approximately 20 work days requiring closure of the Road in September and October of each year*

Rehabilitation Cost Estimate (2001 dollars)	\$ 81.4 to \$ 97.7 million
Rehabilitation Duration	8 to 9 years
Rehabilitation Cost (3% escalation per year)	\$ 98 to \$ 118 million

Alternative 4: Extended Rehabilitation Season

The Extended Rehabilitation Season alternative uses the same concepts as the Comprehensive Shared Use alternative, however the Road is only open to visitors between July 1 and October 1 of each year. By allowing work to proceed unimpeded outside these dates, the schedule of the rehabilitation is reduced by approximately one year. This alternative comes with a high cost, as access and weather conditions could reduce overall productivity considerably.

**Summary of Alternative 4
Extended Rehabilitation Season**

- *Road open to visitors July 1 to October 1*
- *Five-minute delays, 10 a.m. to 2 p.m. Mon-Thu, 10 a.m. Friday to 7 p.m. Sun*
- *Five-minute delays on holidays, and from 10 a.m. to midnight on the day preceding a holiday*
- *30-minute delays, 7 a.m. to 10 a.m. and 2 p.m. to 7 p.m. Mon-Thu*
- *Delays of four hours or less, 7 p.m. to 7 a.m. Mon-Thu*
- *Approximately 10 work days requiring closure of the Road in September*

Rehabilitation Cost Estimate (2001 dollars)	\$ 90.2 to \$ 108.2 million
Rehabilitation Duration	7 to 8 years
Rehabilitation Cost (3% escalation per year).....	\$ 106 to \$ 127 million

Alternative 5: Road Segment Closures

The Road Segment Closure alternative brings forth all of the considerations in the rehabilitation and allows work to proceed on the Road while segments of the Road are closed from 7 pm Sunday to 10 am Friday throughout the visitor season. Traffic is unimpeded on the weekends and holidays. This alternative provides a cost and schedule effective means for rehabilitating the Road, except for visitor impact.

**Summary of Alternative 5
Road Segment Closures**

- *Segments of the Road closed from 7 p.m. Sunday to 10 a.m. Friday*
- *No delays from 10 a.m. Friday to 7 p.m. Sundays and holidays*

Rehabilitation Cost Estimate (2001 dollars)	\$ 72.2 to \$ 83.8 million
Rehabilitation Duration	6 to 7 years

For comparative purposes only, if the Road were totally closed to visitors for the rehabilitation between Avalanche and Sun Point each year, the estimate for the rehabilitation would be in the range of \$65 to \$78 million in constant 2001 dollars (\$75 to \$90 million if escalated 3 % per year) and would take approximately 5 years. Due to the tremendous visitor, social, and economic impacts, a full closure of the Going-to-the-Sun Road may not be a viable alternative for the rehabilitation, and therefore was not included as a separate alternative.

Development of Rehabilitation Alternatives

The road rehabilitation alternatives are based upon the selection of conceptual engineering alternatives developed from field reconnaissance, analysis, discussions with park and FHWA personnel, and literature reviews. The engineering solutions were recommended by a multi-disciplinary team that included planners, engineers, and construction managers with extensive experience in roadway construction in environmentally sensitive mountain terrain with a tourist based economy. Concepts were reviewed with the historic and cultural specialist to assure historic preservation and rehabilitation of those elements considered as contributing to the historic significance to the Road.

The engineering study details the process for arriving at the concepts by investigating the conditions of the Road and determining what solutions could fit within the established criteria:

- Cost effectively restore the Going-to-the-Sun Road while preserving the historic character, fabric, width, and significance;
- Restore the Road to a quality condition;
- Minimize effects on natural, cultural, and scenic resources;
- Provide a world-class visitor experience; and
- Collaborate with others in exploring options that stimulate local and regional economic growth.

This study provides an overview of the conditions and engineering recommendations of drainage, slope stability, retaining walls, guardwalls, and roadway in *Chapter 1: Conditions Assessment*. *Chapter 2: Engineering Analysis and Site Recommendations* provides a summary of the conditions and recommendations of the Road by road sections and road segments. Appendix A provides the detail on maps and spreadsheets of the over 230 sites investigated, including deficiency, recommended

solution, and the magnitude of the effort. The development of the alternatives and the criteria, considerations, and alternatives are presented in *Chapter 3: Development of Rehabilitation Alternatives*.

Conditions Assessment and Engineering Analysis

The overall condition of the Road is summarized in terms of drainage, slope stability, retaining walls, guardwalls, and roadway pavement.

Drainage. Drainage and hydraulic considerations are of paramount importance in construction and rehabilitation work on the Road. Many areas of the roadway and retaining walls continue to degrade as a result of inadequate drainage. The drainage issues should be addressed early in the rehabilitation to avoid further deterioration.

Slope Stability. Of the approximately 50 miles of Road, approximately fifteen miles have slope stability concerns, mostly concentrated in the Alpine Section. The geo-technical concerns fall into six general categories: rockfall; unstable soil slopes above the Road; sloughing and erosion of slopes undercutting the Road or retaining walls; slump failures encroaching on the Road; debris flows onto and across the Road; and avalanche areas and chutes. Each of these issues needs to be addressed in terms of safety, environmental impact, preservation of natural resources, and visitor impact.

Retaining Walls. The stone masonry retaining walls are of considerable historic significance and will require rehabilitation to as near original condition as feasible. The Federal Highway Administration (FHWA) has conducted a thorough inventory and review of these structures with documented evidence regarding deficiencies noted and recommended rehabilitation strategies. The FHWA has established a priority listing of the wall sites and has completed preliminary and final designs for many of the necessary repairs. The findings of the conditions assessment for this study are in agreement with FHWA's conclusions and recommendations.

Guardwalls. The stone masonry guardwalls are of historical significance and, due to their immediate proximity to the traveled way and exposure to the public, usually have a greater visual impact on the visitor than retaining walls. Approximately seven miles of stone masonry walls exist on the Road, most of which will need to undergo some form of rehabilitation work.

Roadway Pavement. The roadway itself requires rehabilitation in many areas. The elements of the roadway considered in the rehabilitation include roadway alignment and width, roadway template adjustment, resurfacing options, and pavement marking. The roadway alignment and width are integral elements of the Road's historical significance and should be preserved. Site-specific consideration should be given for minor deviations in alignment and width in areas where the safety of the visitors, workers, or park personnel may be compromised. This may include intersections, pullouts, trailheads, pedestrian areas, and areas with unstable ground.

In addition to the engineering, design, historic and cultural considerations above, the key elements considered in the overall rehabilitation of the Road includes:

Mobilization and staging. Mobilization and staging costs should be minimized by identifying potential material sources and staging areas as part of the rehabilitation contracts. The most practical staging areas include Logan Pit and Moose Country Pit for work on the west side of Logan Pass and Sun Point for work on the east side. Staging should also occur at each of the rehabilitation sites. Additional staging needs, if necessary, should be outside the park, at the contractor's discretion.

Scheduling. Balance is the key to scheduling the rehabilitation of the Road. There are more factors to consider in developing a schedule for this project than for typical construction projects due to the historic, cultural, environmental, preservation of natural resources, and visitor use issues in the park. These factors include: type and location of work, time and weather conditions, work force availability, environmental impacts, preservation of natural resources, and visitor impacts.

Material Sources. Material specifications should continue to emphasize the status of the Road as a National Historic Landmark. Original stone for masonry work was obtained from within the park and it is recommended that slopes, the original quarry sites, and other potential sources of material from within the park be evaluated and utilized insofar as possible. Using rock from within the park truly provides a cultural framework for the rehabilitation. Naturally occurring rock fall material or material gleaned from rock scaling operations should also be utilized whenever practical.

Maintenance Considerations. The lifecycle of the engineering alternatives has been considered in the recommended solutions. Wherever practical, the most prudent solution with the longest lifecycle is recommended.

Constructibility. Constructibility discussion of the rehabilitation has been ongoing throughout the study. During the field reconnaissance in June 2001, the team included construction managers specifically experienced in environmentally sensitive alpine terrain to help assure the recommended solutions could be built under the specified constraints. Constructibility has been considered in all recommendations included in this study.

Contract Packaging. Contract packaging defines what project sites or types of work are to be included in a given contract. The contract packaging also defines the project delivery method (design-bid-build, design-build, or other means of project delivery). In the rehabilitation of the Road, contract packaging has a significant effect on overall cost effectiveness, scheduling, and impact. Traditional design-bid-build contracts are recommended for the rehabilitation of the Road.

Traffic Management Operations. Traffic management is a critical element in planning the rehabilitation. Traffic management directly affects the cost and duration of the rehabilitation, the visitor impacts, and the socioeconomic impact. The four essential methods of traffic control considered for the rehabilitation efforts are:

- **Alternating one-ways.** Work is restricted to one lane while the other lane is kept open for traffic. Traffic control consists of allowing one direction of traffic to flow while the other direction is stopped. More than 70 percent of the rehabilitation work can be effectively accomplished using alternating one-ways.
- **Intermittent Stops.** When only short periods of time, ten minutes or less, are needed for work on both lanes of the Road, intermittent stops are most effective for controlling traffic and minimizing delays. The method of intermittent stops incorporates alternating one-ways as the basis, allowing one travel lane to be open. When work on both lanes is necessary, traffic can be stopped in both directions. Alternating one-ways resume once the travel lane is cleared. Approximately 20 percent of the rehabilitation will require intermittent stops.
- **Two-way Stops.** When both lanes of the Road are needed to perform work, traffic is stopped in both directions while the work is executed. Traffic remains stopped in both directions until both lanes are available for traffic. Two-way stops range from 30 minutes to four hours or more. Less than ten percent of the rehabilitation will require two-way stops

- **Closures.** Certain operations that encompass the entire roadway width will require sustained closures of segments of the Road. These include complete subgrade or retaining wall reconstruction in areas where the width of the roadway does not allow enough room for both a travel lane and sufficient work area. Less than two percent of the rehabilitation will require closures of more than four hours.

Visitor Management Strategies. The fundamentals of visitor management include those means to maintain or enhance the visitor experience during the rehabilitation. This translates into minimizing the disruptions to the visitor's experience. Traffic management strategies are critical in managing visitors. The basic concept is to allow the freest movement of traffic during peak visitor use, and schedule delays during lower visitor use, by balancing the needs of the visitor with the need to cost effectively rehabilitate the Road. Visitor management considers circulation and staging, transportation, parking, comfort stations, and trails. Interpretative and orientation information is a critical element in visitor management and can also provide new opportunities for interpretation on the Road, its historic significance, and its rehabilitation.

Risk Management. Safety, both for the traveling public and rehabilitation personnel, is of paramount importance. Safety management should include traffic management through construction zones, rockfall areas, physical safety features, hazard alert, and catastrophic events.

Operations and Maintenance

Maintenance of the capital, historical, and recreational value of the Road, should be accorded the significance due a world-class visitor destination and National Historic Landmark. In order to do this, it is imperative that sufficient funds and other resources be allocated to sustain a fully staffed, fully funded, and fully functional maintenance program tailored to the specific needs of the Road. Currently, the funds allocated to maintenance of the Road are less than one third of that needed to provide adequate maintenance.

Operation and maintenance activities should continually be assessed, quantified, and prioritized. With only emergency repairs scheduled for the Road in the next few years, it is essential to assess the current needs and develop a prioritized list of maintenance activities. The information provided in this study on the deficiencies and recommended solutions provides a good source to determine what work could be

undertaken as maintenance functions. An overall prioritization for consideration could be as follows:

- Ensure safety of the traveling public
- Provide emergency traffic control and services when needed
- Slow deterioration by addressing drainage and erosion
- Preserve natural resources
- Minimize impact to Road during snow removal
- Maintain infrastructure for critical structures
- Provide localized pavement sealing
- Provide general maintenance and repairs based on priority list
- Monitor geotechnical instrumentation
- Inspect features of the Road and identify deficiencies
- Maintain a log of deficiencies with priorities and schedule

As the Road and its features age and deteriorate due to environmental and weather conditions and vehicular usage, maintenance and rehabilitation costs become more and more of a factor in protecting the capital investment and historic nature of the Road. Regular roadway inspections and monitoring programs should be developed and implemented in order to monitor the roadway conditions and provide a basis for continuing maintenance operations.

Conclusions and Recommendations

The Going-to-the-Sun Road is in serious need of rehabilitation. Unless funding can be dramatically increased for rehabilitation and maintenance, the Road will continue to deteriorate, visitor safety will be compromised, and the potential for catastrophic failures will increase. The cost and time for rehabilitation, operations, and maintenance will continue to escalate until corrective action is taken.

The alternatives for the rehabilitation of the Road represent a range of costs, schedules, and visitor impact that can be used to develop an overall plan for rehabilitation. Selection of the most appropriate visitor management, transportation, and socioeconomic strategies needs to be in concert with the rehabilitation alternative selected to control the impact.

Throughout the study, specific areas of rehabilitation are identified and solutions are recommended. A summary of the recommendations is as follows:

Executive Summary

- Visitor safety issues exist and need to be addressed as soon as possible with respect to localized slope stability.
- The deterioration of the roadway, drainage features, retaining walls, and guard-walls continues. This deterioration needs to be slowed or stopped as soon as possible. It is critical to improve drainage now to slow the deterioration. Additional funding is strongly recommended for drainage improvements in the next few years until an overall rehabilitation plan can be implemented.
- Annual maintenance funding must be increased substantially to protect the Road from further deterioration and to protect the capital investment once the Road is rehabilitated.
- In addition to the critical retaining wall design and rehabilitation projects underway, designs for the most critical areas must advance as soon as possible to assure that rehabilitation efforts will be cost effective and within the criteria established for the rehabilitation. Rehabilitation design criteria must include historic, cultural, and environmental considerations, as well as strategies for visitor management. We recommend that during the remaining process of developing the EIS, design plans for rehabilitation of priority sites continue, with the goal of having design plans ready as funding becomes available. We recommend that additional funding be appropriated as soon as practical to design and rehabilitate the priority sites with an emphasis on safety and prevention of further deterioration.
- The site recommendations suggested in this study were made without the benefit of subsurface geotechnical information and site-specific hydrology information. The recommendations are conceptual in nature, primarily generated to provide a feasible solution and a magnitude of the rehabilitation effort in terms of cost and schedule. It is recommended that geotechnical monitoring instrumentation be installed at the sites recommended in the study, and that subsurface investigation and a localized hydrology study be conducted during preliminary design to determine the final design for each of the sites.
- As the overall rehabilitation effort may not get underway for a few years, it is recommended that, in addition to the items mentioned above, certain pre-rehabilitation efforts be implemented as soon as possible. These include the collection and stockpiling of rocks suitable for wall rehabilitation, increased collection of plant seeds for landscaping, pre-qualification of contractors, and the development of a

comprehensive Going-to-the-Sun Road Design Standards Manual that consolidates the historic, cultural, environmental, and visitor use requirements into the design criteria and typical plans for the rehabilitation.